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THE INFLUENCE OF WASTE WATER COMPOSITION ON THE PUMPING SYSTEM CORROSION

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ABSTRACT

Wastewater piping systems in urban agglomerations or industrial areas have problems with the wear and tear of equipment and water transport pipelines used. The problems are related to hydromechanics wear and corrosion due to the presence of solid particles transported with water and due to the residual chemical compounds resulting from industrial technological processes, as well as the presence of biological waste from domestic consumers. In the paper are presented the corrosive characteristics of the waste waters and a review of the effects of wear and corrosion in the case of submersible pumps is made.

KEYWORDS: wastewater, corrosion, wear

1. Introduction

Industrial or domestic wastewater pumps are used to transport fluid containing chemical compounds and industrial and organic wastes from the user to the treatment plants. They are also used for drainage of surface water (floods) and sewers (for transport between treatment plants) [1].

Pumps are recommended for transport: liquid phases containing solvents and chemical solvents, as well as powders, sand, colloidal substances and suspensions; fluids containing air or gas bubbles at the surface of the water or dissolved in the interior; crude sludge; rain water; wastewater with faces [2].

Drainage pumps may be provided with a shredder, which is intended to grind the slurry, in order to facilitate the solid matter transportation of the wastewater. Wastewater pumps (domestic and industrial) are generally high power centrifugal pumps working under heavy conditions because the water contains powerful organic and nonorganic corrosive agents as well as suspensions and abrasive particles of various sizes and shapes [3-5].

2. Wastewater composition

The wastewater composition varies, containing sewage waste including pathogenic bacteria, organic and nonorganic particles, emulsions, dissolved gases, etc., with a pH ranging from 6 to 9 (mainly acid pH).

The most corrosive is sulfuric acid that is found in high concentration in waste water [2, 6]. During operation, a mechanical wastewater pump must bear various mechanical and chemical stresses, such as:

- mechanical shock of different intensities, variable contact angles of the particles. The abrasion degree of the particles varies according to their shape and size [7];
- thermal and mechanical action, as the pump works outdoors in winter must withstand temperatures down to -35 °C (at temperatures below 0 °C there is the risk of water freezing within the plenum and transport pipes, micro-cracks occurring due to the increase with 9% of the volume of frozen water) and summer to 50 °C; that work in the submerged state must withstand the speed and strength of the water with abrasive particles;
- cavitation due to turbulent waste water is a danger to the integrity of the pump sub-assembly;
- acid pH of water which increases the content of active ions and chemical reactivity of the liquid;
- the corrosion of sulfuric acid and sulfur dioxide dissolved in water, resulting from the decomposition of the organic origin substances;
- enhanced corrosion due to the presence of dissolved oxygen in the transported liquid, which modifies the acidity of the water [8];
- accelerated flux corrosion represents the removal of the protective oxide layer from the pump

metal (especially in low-alloy steels and gray cast iron).

The speed of this process is determined by the oxygen content, the leakage rate and the chlorine content [9, 10];

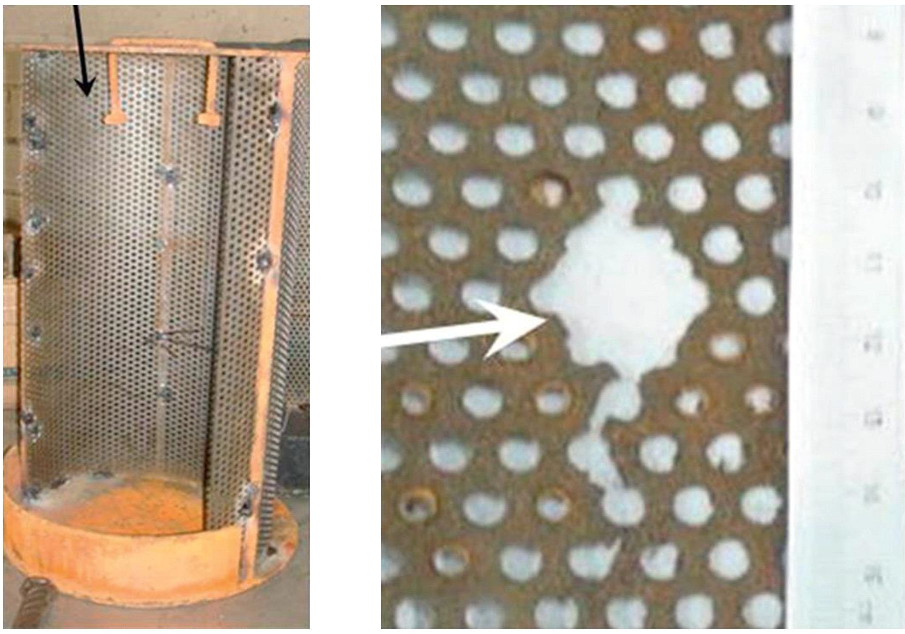
- operating irregularities due to the variable viscosity of the wastewater and the presence of suspended particles of different sizes [11, 12];

- the action of aerobic and anaerobic bacteria on the pump metal;

- the chemical attack of hydrogen sulfide (H_2S), which is produced by sulfur-reducing bacteria in wastewater that flows into sewage.

a) b)

Fig. 1. *a) Holes in a gray cast iron housing due to the presence of sand in the transfer fluid; b) Intercrystalline corrosion in the cast iron casing favorized by the presence of solid suspensions*



a) b)

Fig. 2. *Severe degradation of austenitic stainless steel due to the combined action of mechanical abrasion and acid corrosion of the liquid transported medium; a) a filter; b) detail*

Fig. 3. *Submerged wastewater pump*

In addition to factors such as pH, temperature and organic wastewater, the flow velocity and the impact of specific compounds in the liquid must be incorporated into the sulfide reactions and bacterial growth.

The wastewater pumps materials must be compatible with the pumped liquid solution so that the wear and corrosion of the materials forming the inner chambers and the transport elements are within tolerable limits.

Because the pump is the heart of the filtration system, it must have the ability to supply and maintain the desired flow and pressure, as the dirt accumulates on the filter material [13, 14].

3. Influence of wastewater composition on corrosion of pumping systems

Wastewater represents a chemical aggressive environment due to the presence of corrosive and abrasive elements, such as:

- dissolved oxygen;
- household waste, such as chloride, fluoride, sodium, organic dejection substances;
- acids formed from the decomposition of biological substances;
- sulfur compounds (SO_2, H_2S, H_2SO_4, etc.);
- aerobic and anaerobic bacteria that create biogenic acids (produced by a biological process);
- fungi and suspensions of biological residues, gravel, sand and other solids of organic and nonorganic nature.

Authors studied the characteristics of wastewater corrosion [15-18].

Figure 4 shows the classic representation of partially filled pipeline containing waste water with a variety of organic and sulfur compounds. Typically, the channel is half filled and the pipe speed is maintained at about 0.6 m/s.

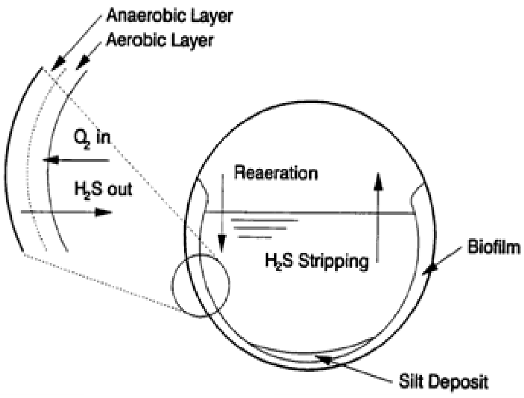


Fig. 4. *Typical sewage section* [19]

Glass and heavy organic particles are deposited on the bottom, while the bacterial deposits develop on the channel walls to form a biofilm or slurry layer. This layer of film and biofilm provides an excellent growth medium for bacteria, protected by the shear forces of the flowing waste water.

This channel contains several micro-media: the space above the liquid is usually filled with abundant oxygen air; the liquid may be either aerobic or anaerobic, depending on the oxygen demand and the reaction speed; the layers of silica and biofilm may also be aerobic or anaerobic.

Wastewater may contain iron oxides or iron chlorides, their presence giving a red color, earthcolor to the water, and the presence of manganese or oxides giving a black color to wastewater. Oxides can also be found in the form of granules and are in the form of fine powders subsequently dissolved in water or as mud or sludge [20].

The transport pipelines are clogged with powdered substances and solid microparticles forming wall-adherent protuberances.

The percentage of chlorides and sulphides in water increases the amount of deposits on the walls of the pipes and the corrosion of the transport system.

At the fluid displacement speed and laminar flow, there is the possibility of chemical corrosion reactions (oxidations, etc.) carried out by ionization and low speed diffusion [21].

In the case of turbulence flows, the laminar layer on the pipe walls is thin and then the corrosion speed is higher. Turbulence swirls are enhanced by the presence of depositions on the walls. So, the more deposits on the walls, the more intense corrosion.

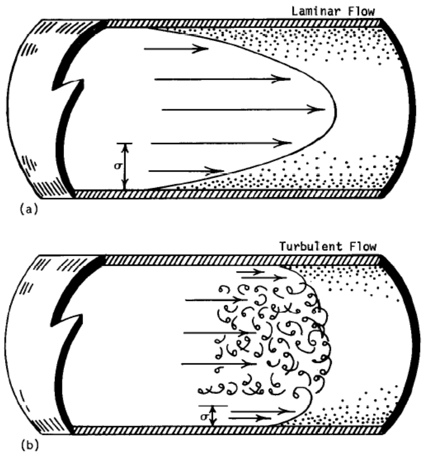
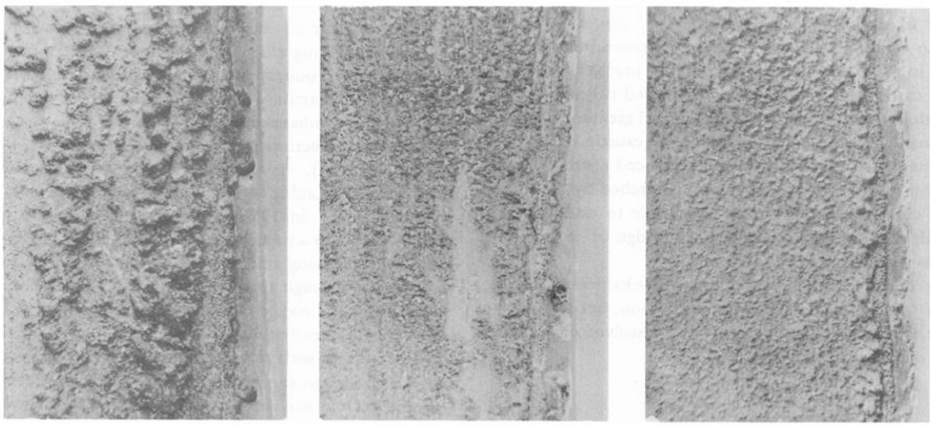


Fig. 5. *Comparison of oxygen diffusion in laminar flow (a) and turbulent (b)* [15]



0.06 m/s 0.33 m/s 0.67 m/s

Fig. 6. *The effect of deposition velocity on turbulent flow* [15]

Therefore, in wastewater, turbulences that forms at high flow rates and velocities, allow oxygen to reach the inner surface of the pipeline more quickly, and corrosion rates are higher.

Types and concentrations of contaminants in waste water from domestic sources are well known - fats, oils, grease, soaps, organic matter, dirt, human waste, food waste, etc. - normally in total concentrations below 1000 ppm (0.1%).

The most common chemical contaminants in domestic water are chlorides, nitrogen compounds and a wide variety of organic compounds. Sulfate and phosphate ions are present.

The household wastewater pH is typically between 6 and 7, lightly on the neutral side where there is greater use of soaps and household cleaning materials, most of which are slightly alkaline to enhance the detergents efficiency.

Sewage and other wastewater contain significant levels of biological and organic materials, including many bacteria that remain active in waste streams.

From the corrosive point of view, the most important types of bacteria are those that metabolize sulfur compounds because this microbiological activity can produce acid chemicals that are corrosive to concrete, steel or iron. Some bacteria also oxidize ferrous ions to ferric ions, which makes the local environment more corrosive to carbon steel.

4. Analyzed wastewater pumping system

A single-channel, low-pressure centrifugal pump was analyzed, both macroscopically and SEM analysis to highlight areas with significant wear and corrosion.

It can be seen that the inner part of the pump rotor, which works submerged in the liquid resulting from the domestic activities, is much corroded.

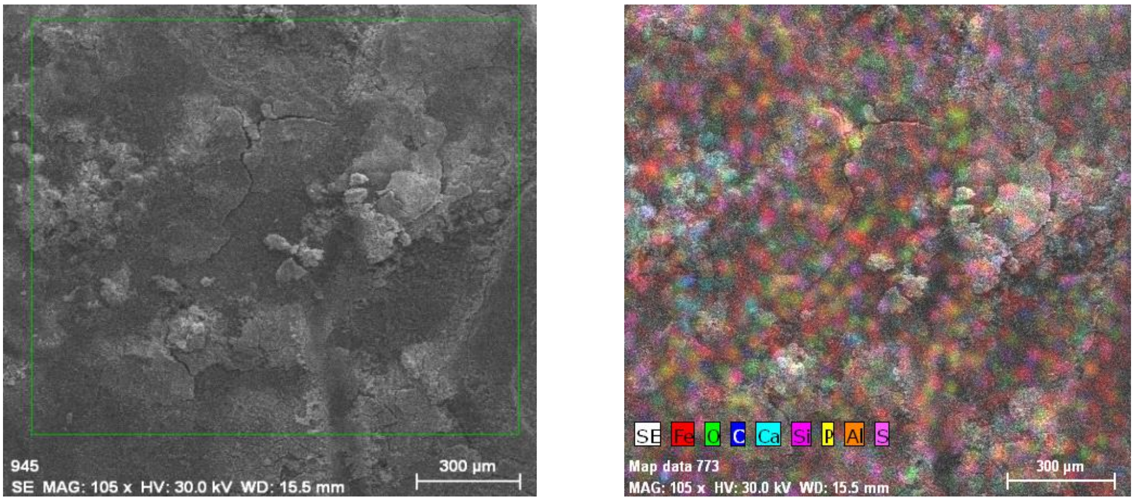
The rotor material was analyzed on the Foundry Master spectrometer and found to be a nodular cast iron alloyed with Ni and W. The chemical composition is shown in Table 1.

a) b)

Fig. 7. *Single-channel low pressure centrifugal pump; a) a rotor; b) rotor corroded and worn area*

Table 1. *The chemical composition of the pump rotor*

Element	Fe	C	Si	Mn	P	S	Mo	Ni	W	Cr	Balance
Percent	78.1	4.5	2.55	0.15	0.8	0.15	0.2	9.34	2.29	0.08	1.84



a) b)

Fig. 8. *SEM microstructure of the pump rotor*

SEM analysis shows the presence of mixed oxide particles of waste substances from the wastewater. An EDX analysis was also carried out showing a distribution of the substances on the corrosion film area.

5. Conclusions

The analysis of the corrosive factors in the working environment of the waste water pumps requires finding efficient and relatively cheap solutions for improving wear and corrosion resistance of the transport galleries inside the pumps.

Materials used in the construction of pumps (brass, medium and high alloyed steels with Cr and Ni, alloyed cast iron) have good corrosion resistance characteristics, but are limited to wear resistance.

The pump analyzed is made of chromium and tungsten alloyed cast iron and shows in the work channel material rupture and tearing due to the solid particles moving with high speed into the pump cavities.

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